were selected to reduce the number of unique shims and to reduce potential errors from stacking and aligning shims.

[0109] Shim **420** is the same as shim **360**.

[0110] Shim **430** is the same as shim **350** except that there is no slot for the combustion fuel. The fuel was mixed with the air in shim **350** and consumed or nearly consumed in the reactor.

[0111] The remaining shims are the same as shims **340**, **330**, **320**, **310**, and **302** respectively except without fuel holes. Equal shim thickness and numbers of shims are used as shims **340** to **302** to create a near symmetric device. This reduces fabrication time and cost.

[0112] The catalyst used in the reformer channels, for the case of methane steam reforming in the slots and combustion in the holes to provide the endothermic reaction heat, contained a catalyst of 13.8%-Rh/6%-MgO/Al_2O_3 on a metal felt of FeCrAlY alloy obtained from Technetics, Deland, Fla. The reforming catalysts were prepared using a wash-coating technique based on FeCrAlY felt with 0.01" thickness and 90% porosity. Before wash coating, metal felt was pretreated by a rapid heating to 900° C. in air for 2 hours. To enhance the adhesion between the metal surface and the catalyst, a dense and pinhole-free interfacial layer was first coated onto the oxidized FeCrAlY felt by metal organic chemical vapor deposition (MOCVD). This interfacial layer can be Al_2O_3, Al_2O_3+SiO_2, or TiO_2, etc. For example, when TiO_2 was coated, titanium isopropoxide (Strem Chemical, Newburyport, Mass.) was vapor deposited at a temperature ranging from 250 to 900° C. at a pressure of 0.1 to 100 torr. Titania coatings with excellent adhesion to the foam were obtained at a deposition temperature of 600° C. and a reactor pressure of 3 torr. This layer not only increases the adhesion between metal felt and the catalyst, it also protects the FeCrAlY from corrosion during the steam reforming reaction. 13.8 wt % Rh6 wt % MgO/Al_2O_3 powdered catalyst was prepared by 1) calcining a high surface area gamma-alumina at 500° C. for 5 hours; 2) impregnating the gamma alumina with MgO using the incipient wetness method with an aqueous solution of magnesium nitrate; and obtaining an MgO modified gamma alumina support; 3) drying the modified support at 110° C. for 4 hours followed by 4) a second calcination at 900° C. for 2 hours; 5) impregnating the modified support with Rh_2O_3 with the incipient wetness method from a rhodium nitrate solution; 6) followed by a final drying at 110° C. for 4 hours and a 7) final calcinations at 500° C. for 3 hours to obtain a powder of the supported catalyst. Catalyst coating slurry was prepared by mixing powder catalyst aforementioned with de-ionized water in the ratio of 1:6. The mixture was ball-milled for 24 hours to obtain coating slurry containing catalyst particles less than 1 micron. The heat-treated and CVD coated felt was wash-coated by dipping the felt into catalyst slurry. The wash coating process may be repeated to obtain desired weight gain. Between each coating, the felt coated with catalyst was dried in an oven at 100° C. for 1 hour. The coating procedure is repeated to achieve desired coating thickness or catalyst loading. After the final coating step, the catalyst was dried overnight in an oven at 100° C. and calcined by heating slowly in air at rate of 2° C./min to a temperature in the range of 300 to 500° C. The amount of catalyst coated was measured to be 0.1 gram catalyst per square inch (6.5 cm^2) of felt. Prior to steam reforming testing, the engineered catalyst felt was subjected to an activation treatment, preferably reduction at 300-400° C.

[0113] The integrated combustion catalyst can be a wash-coated catalyst that is applied directly to the interior Inconel walls of the ICR device. The Inconel surface is first cleaned, ultrasonically if possible, in hexane, nitric acid (20%) and acetone (or propanol). Preferably, the cleaning solutions are flowed over the Inconel surfaces. A native chromium oxide layer is then formed on the Inconel surface by heating in air (flowing, if possible) at 3.5° C./min to 500° C., and held at 500° C. for 2 hours. The temperature is then increased at 3.5° C./min to 950° C., and held at 950° C. for 2 hours. The Inconel is then allowed to cool to room temperature at a rate no faster than 5° C./min. The active palladium component is then applied to the chromia layer by submersing the required deposition area in a 10-wt % solution of palladium nitrate. This is accomplished either by static submersion, or by pumping the fluid into a device to a required liquid level. The solution is then allowed to remain in contact with the deposition surface for 2 minutes. The solution is then removed from contact with the Inconel surface, and the amount of palladium remaining is calculated through a difference measurement. In the case of channel coating, nitrogen is flowed through the channel do ensure no plugging occurs. The catalyst is then dried at 100° C. for one hour, under vacuum if possible. The catalyst is then calcined by heating at 3.5° C./min to 850° C., held at 850° C. for 1 hour. The catalyst is then allowed to cool to room temperature at a rate no greater than 5° C./min.

Example 2

[0114] A high pressure vaporizer **200** was constructed that uses a flow of hot air to heat and partially vaporize water flowing in the countercurrent direction. The water is pressurized to 20 atmospheres while the air is at nearly atmospheric pressure. Design flow rates are 20 mL/minute of water at 280 psig inlet and an inlet temperature of 210° C. and 247 SLPM of air at slightly above atmospheric pressure (8 psig inlet) and an inlet temperature of 279° C. Nominal operating temperature is 215° C. The design point for steam quality at the outlet is 50%.

[0115] The central area of the vaporizer contained 1.7 inches (4.3 cm) thick stack of identical shims **210**, each having a thickness of 0.010" (0.025 cm). The individual channels in a shim are offset half their width from the channels below and above. Since every other layer is at higher pressure, this provides load support with a reduced number of supports **214** (where a support **214** (or alternately called a rib) is defined as the material between channels in the direction of width (that is, the distance within a shim between channels as measured in the direction of longest dimension of each channel, or, where there is not a longest dimension, in the shortest dimension that is perpendicular to thickness), but not including the web thickness that is disposed between channels in the direction of height). For the same stress, each channel is wider than it would be with aligned support webs. This provides more open area to reduce pressure drop, fouling and minimizes required thickness between layers reducing resistance to conductive heat transfer.

[0116] The features in the main body were created by photochemically etching through a flat piece of stainless